

**V-05.01 Introduction**

The North Dakota Department of Transportation (NDDOT) will follow its standard practices for the hydraulic and structural design of pipes. The NDDOT will adopt additional performance criteria that will be used to evaluate the acceptability of alternate pipe materials based on application, local, and regional factors.

**V-05.02 Selection Considerations**

The NDDOT will evaluate the risk associated with the performance of the pipe materials and the long-term performance of the completed end product. Risk will be considered to the extent that it is influenced by the pipe, other materials, or installation techniques as they are used in the construction practice. It is the owner's prerogative and responsibility to establish reasonable performance standards. Project design and material selection is inherently based on balancing the engineering requirements with the budgetary constraints of the project.

The Public's expectations are focused on long-term performance of the subject roadway. It is incumbent on the NDDOT to consider all factors (influenced by the design and selection of materials) in terms of their contribution to the risk of non-conformance to performance standards and expectations.

The NDDOT proposes to mitigate its risk by following AASHTO and ASTM national standards for pipe material. Installation requirements defer to AASHTO standards, the experience and research studies from the NDDOT, and experience of other DOTs. Manufacturers' recommendations are also considered.

When designing standard centerline culverts and approach culverts it may be necessary to eliminate certain types of pipes because of physical constraints (ex matching existing inverts). Also, in some cases, a larger size conduit may be required when using pipes with "n" values higher than 0.013.

Storm Drain pipe shall be limited to smooth interior pipe with a maximum Manning's "n" value of 0.013. This enables the use of Reinforced Concrete Pipe, and Plastic, as well as Spiral-Rib Metal Pipe which has a much smoother interior than traditional Corrugated Metal Pipe.

Local or regional considerations, as they relate to engineering, cost, or performance criteria, will be used in evaluating the acceptability of alternate pipe materials and may be studied on a case by case basis where it is deemed appropriate.

This section describes the selection procedure that supports the general policy statement. It refers to the processes and procedures that identify the specific engineering, cost analysis, and performance criteria used to evaluate the acceptability of alternate pipe materials. It is NDDOT's practice to allow alternate pipe materials where they can be used.

All limitations to materials will be documented and records will be kept in order to ensure valid engineering reasoning for any material limitations.

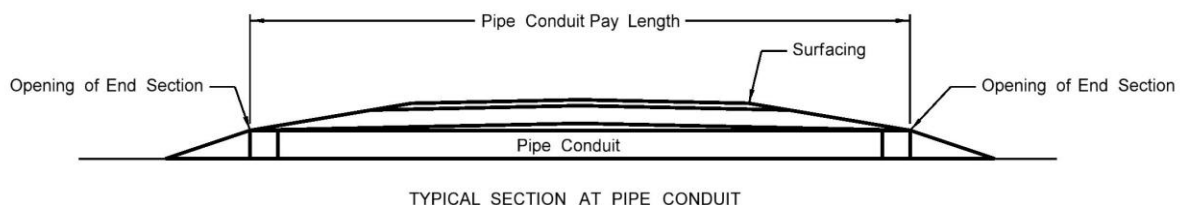
### V-05.03 Bid Items

Bid items for Pipe have been broken into 3 main categories, as follows:

1. **Pipe Conduit \_\_ IN:** Typical transverse centerline culvert
2. **Pipe Conduit \_\_ IN – Storm Drain:** Urban drainage
3. **Pipe Conduit \_\_ IN – Approach:** All approach pipe designations.

The plans, specifications and bid documents for the project will identify all alternate pipe materials that, based on the results of the evaluation, are determined to be acceptable for the following general or specific applications.

The pay length for pipe conduit is measured along the top of the conduit between the openings of the end sections, as shown in the diagram below. If cross sections are used to calculate the length, the topsoil should be included on the section to ensure the proper total length of conduit is found. Lengths should be calculated to the nearest foot. The barrel lengths for Reinforced Concrete Pipe should be calculated and included on the Pipe List plan sheet.



For centerline culvert extensions, the existing end sections should be reused if they are in a condition to do so. The additional pipe conduit material would be paid for by the linear foot as "Pipe Conduit \_\_ IN" and the end section would be paid for as "Remove and Relay End Section – All Types & Sizes." If the end sections need to be replaced, they should be paid for by the each installed of the type and size required. For example a 30" concrete pipe extension needing a new end section would be paid for "End Sect – Conc Reinf 30 IN" EA. Approach culvert extensions and end sections shall follow the same method used for new installations as unlike materials can be used to extend approach conduits (see Table 2).

**V-05.04 Design Service Life**

Design Service Life (DSL) is typically defined as the period of service without a need for major repairs. Drainage structures are not assumed to be at or near the point of collapse at the end of their design service life. DSL is the period of little to no rehabilitative maintenance. Highway drainage structures are usually designed with the goal of providing some pre-selected minimum number of years of DSL.

The DSL for reinforced concrete pipe is typically the period from installation until reinforcing steel is exposed, or a crack signifying severe distress develops. The DSL for metal pipes used for Mainline Drainage and Storm Drain Trunk Lines & Lateral Drainage applications will normally be the period in years from installation until metal loss reaches the point of perforation of any point on the culvert. The DSL for metal pipes used for Approach Drainage applications will normally be the period in years from installation until the point of metal loss and perforation on the pipe invert. The DSL for plastic pipe may be considered at an end when excessive cracking, perforation, or deflection has occurred.

**V-05.05 Pipe Material**

Table 1 lists references to the NDDOT *Standard Specifications for Road and Bridge Construction*. These pipe materials are considered as appropriate for Mainline Drainage, Approach Drainage, and Storm Drains; with the exception of Plastic Pipe which is not allowed in Mainline Drainage applications, or Storm Drain Trunk Lines and Lateral Drainage under paved roadways due to unacceptable risk.

For guidelines on the selection and use of alternate pipe materials for specific applications see Table 2. The list of factors to be considered is not intended to be all inclusive, therefore a proper engineering analysis is required for all installations. For large installations, the analysis should include installation cost comparisons.

**Table 1 – Pipe Materials**

<b>Material</b>	<b>NDDOT Specifications</b>
Concrete Pipe	714.02 & 830.01
Metal Pipe	714.02 & 830.02
Plastic Pipe	714.02 & 830.03

Pipe materials that the Department does not have a history with in drainage applications are generally not listed on Tables 1 and 2. However, the Department is willing to review new products to determine if the product could be suitable for highway use in the future.

The NDDOT may consider new pipe materials for inclusion in future projects based on that material's conformance with national standard specifications (AASHTO or ASTM), product

performance history, NDDOT or other DOT research findings, etc. If a product or material is found to be acceptable, it may be considered for evaluation on specific projects or on an experimental basis, before it has been included into the NDDOT Standard Specifications.

Table 2 – Guidelines for Alternate Pipe Materials

Application	Factors to be Considered	Materials to be Considered	Notes
<b>Mainline Drainage</b> Design Service Life - 75 Years	<ul style="list-style-type: none"> <li>- Hydraulic Capacity</li> <li>- Structural Capacity</li> <li>- Service Life</li> <li>- Soil / Water Corrosivity</li> <li>- Fill Height</li> <li>- Bed Load Abrasion</li> <li>- Resistance to Fire</li> </ul>	<ul style="list-style-type: none"> <li>- Concrete Pipe (Section 830.01)</li> <li>- Metal Pipe (Section 830.02)</li> </ul>	<ol style="list-style-type: none"> <li>The materials listed for each application in this table are a preliminary estimate of possible alternate materials. <b>Not all of the materials may be feasible in all situations and additional engineering criteria may require evaluation.</b></li> <li>Some materials may not have adequate hydraulic capacity, service life, corrosion and abrasion resistance, structural capacity, and resistance to fire damage.</li> <li>A specific pipe material may be used if properly documented in the Hydraulic Study in accordance with these Guidelines. The NDDOT Design Manual and these Guidelines shall be used when evaluating and selecting pipe materials for use on NDDOT projects</li> <li>To fully document the alternate pipe material selection, the following items should be included during the determination of Hydraulic and Structural Requirements as appropriate:               <ol style="list-style-type: none"> <li>A hydraulic analysis for each culvert or storm drain shall be completed.</li> <li>Determination if abrasion protection is required based on the channel bed material and estimated flow velocity.</li> <li>Review of regional corrosive soil maps to determine the applicable pipe materials, gauges, and coatings that provide an adequate service life for the application.</li> <li>Verification to determine that the minimum and maximum fill height for each alternate pipe material and shape is applicable to each crossing.</li> <li>Review of project scoping reports and District input to determine if ditch burning is anticipated near exposed pipe. If ditch burning is anticipated, plastic or coated metal pipe shall not be used without the addition of non-flammable segments and/or end treatment as determined by the Designer.</li> </ol> </li> <li>The fill height tables for various pipes are located in NDDOT Design Manual Section V-05 Appendix A. These tables shall be used to determine the applicability of the various alternate pipe materials, shape, gauge, and wall thickness. If tables for an allowable pipe material do not exist, manufacturer's recommendations shall be followed.</li> <li>All metal pipe used for mainline, paved intersecting roadways, and storm drain trunk lines and laterals shall be deflection tested a minimum of thirty days after the pipe is installed. The Contractor shall pass a nine point mandrel or other approved object through the pipe to check for deformation. The deformation test shall take place under the observation of the Engineer. The mandrel diameter shall not be less than 95% of the inside diameter of the pipe. If the pipe has deformed more than 5%, it shall be replaced at the Contractor's expense. Another thirty day waiting period will commence upon installation of the replacement pipe prior to retesting.</li> </ol> <p>Metal and thermoplastic pipe used for approaches shall be visually inspected, and at the Engineer's discretion, may require deflection testing.</p>
<b>Approach Drainage</b> Design Service Life - 40 Years	<ul style="list-style-type: none"> <li>- Hydraulic Capacity</li> <li>- Structural Capacity</li> <li>- Service Life</li> <li>- Soil / Water Corrosivity</li> <li>- Fill Height</li> <li>- Bed Load Abrasion</li> <li>- Resistance to Fire</li> </ul>	<ul style="list-style-type: none"> <li>- Concrete Pipe (Section 830.01)</li> <li>- Metal Pipe (Section 830.02)</li> <li>- Plastic Pipe (Section 830.03)</li> </ul>	
<b>Pipe Extensions</b>	<ul style="list-style-type: none"> <li>- Review Remaining Pipe Service Life</li> <li>- Hydraulic Capacity</li> <li>- Structural Capacity</li> <li>- Service Life</li> <li>- Soil / Water Corrosivity</li> <li>- Fill Height</li> <li>- Bed Load Abrasion</li> <li>- Resistance to Fire</li> </ul>	<ul style="list-style-type: none"> <li>- Mainline:               <ul style="list-style-type: none"> <li>• Match Existing Material</li> </ul> </li> <li>- Approach:               <ul style="list-style-type: none"> <li>• Unlike Materials Acceptable</li> </ul> </li> </ul>	
<b>Storm Drain Trunk Line and Laterals</b> Design Service Life - 75 Years	<ul style="list-style-type: none"> <li>- Hydraulic Capacity</li> <li>- Structural Capacity</li> <li>- Service Life</li> <li>- Soil / Water Corrosivity</li> <li>- Fill Height</li> <li>- Bed Load Abrasion</li> <li>- Water Tight Joints</li> </ul>	<ul style="list-style-type: none"> <li>- Concrete Pipe (Section 830.01)</li> <li>- Metal Pipe (Section 830.02)</li> <li>- Plastic Pipe* (Section 830.03)</li> </ul> <p>* Plastic Pipe is not allowed under any paved roadway.</p>	

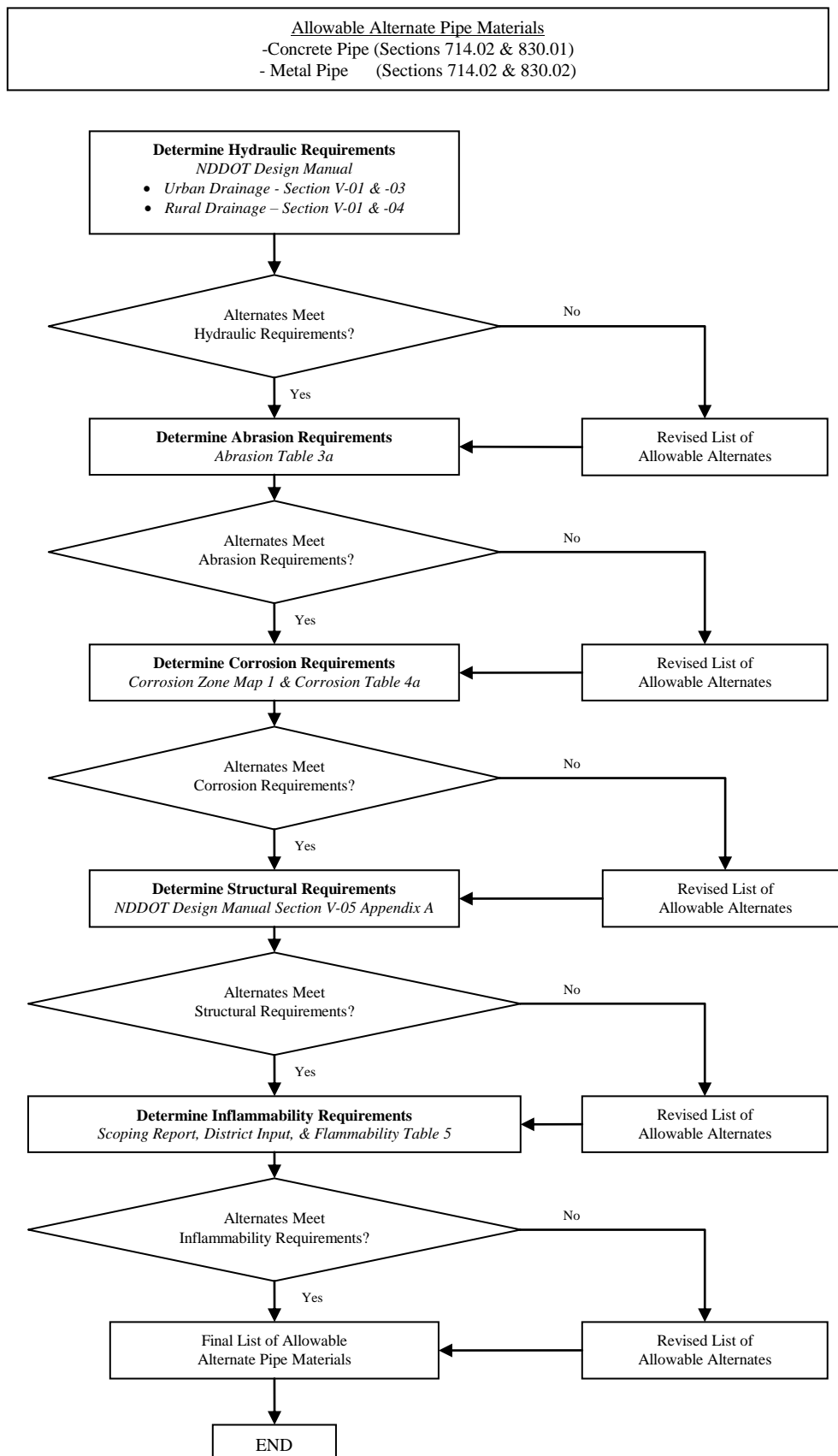
**V-05.06 Pipe Material Selection Process**

The Designer will follow the selection steps shown in the flow chart for the specific pipe application. Flow charts titled Mainline Drainage, Approach Drainage, and Storm Drain Trunk Line and Laterals; guide the Designer through the process of evaluating the critical criteria to determine the alternate pipe materials allowable for the project application.

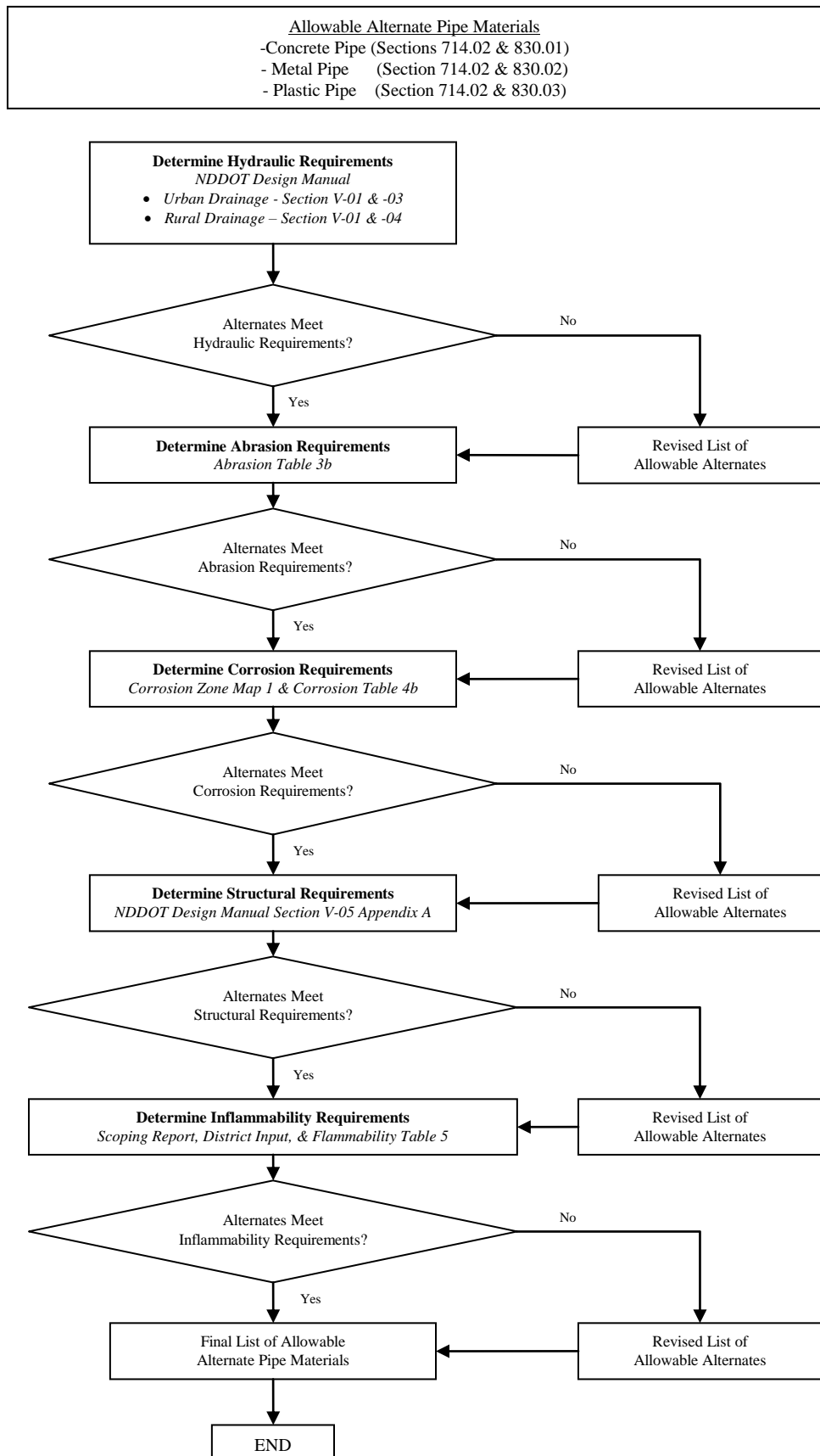
The Designer will use the following resources in the Procedure based for the specific design application:

- Application Requirements (Allowable Pipe Materials)
  - Pipe Materials – Table 1 (in this document)
  - Guidelines for Alternate Pipe Materials – Table 2 (in this document)
  - NDDOT Standard Specifications for Road and Bridge Construction
    - Sections 714 and 830
    - NDDOT Supplemental Specifications
- Hydraulic & Hydrostatic Design Requirements
  - NDDOT Design Manual
    - Rural Drainage – Section V-01 & -04
    - Urban Drainage – Section V-01 & -03
- Abrasion Requirements
  - Abrasion Tables 3a and 3b (in this document)
- Corrosion Requirements
  - Corrosion Zone Map 1 (in this document)
  - Corrosion Table 4a – Mainline Drainage (in this document)
  - Corrosion Table 4b – Approach Drainage (in this document)
  - Corrosion Table 4c – Storm Drain Trunk Line & Lateral Drainage (in this document)
- Structural Requirements
  - Concrete Pipe : NDDOT Design Manual Section V-05 Appendix A
  - Metal Pipe: NDDOT Design Manual Section V-05 Appendix A
  - Plastic Pipe: Manufacturer's Recommendations
- Inflammability Requirements
  - NDDOT Project Scoping Report
  - NDDOT District Engineer Input
  - Flammability Table 5

### Mainline Drainage Flowchart (Design Service Life – 75 Years)

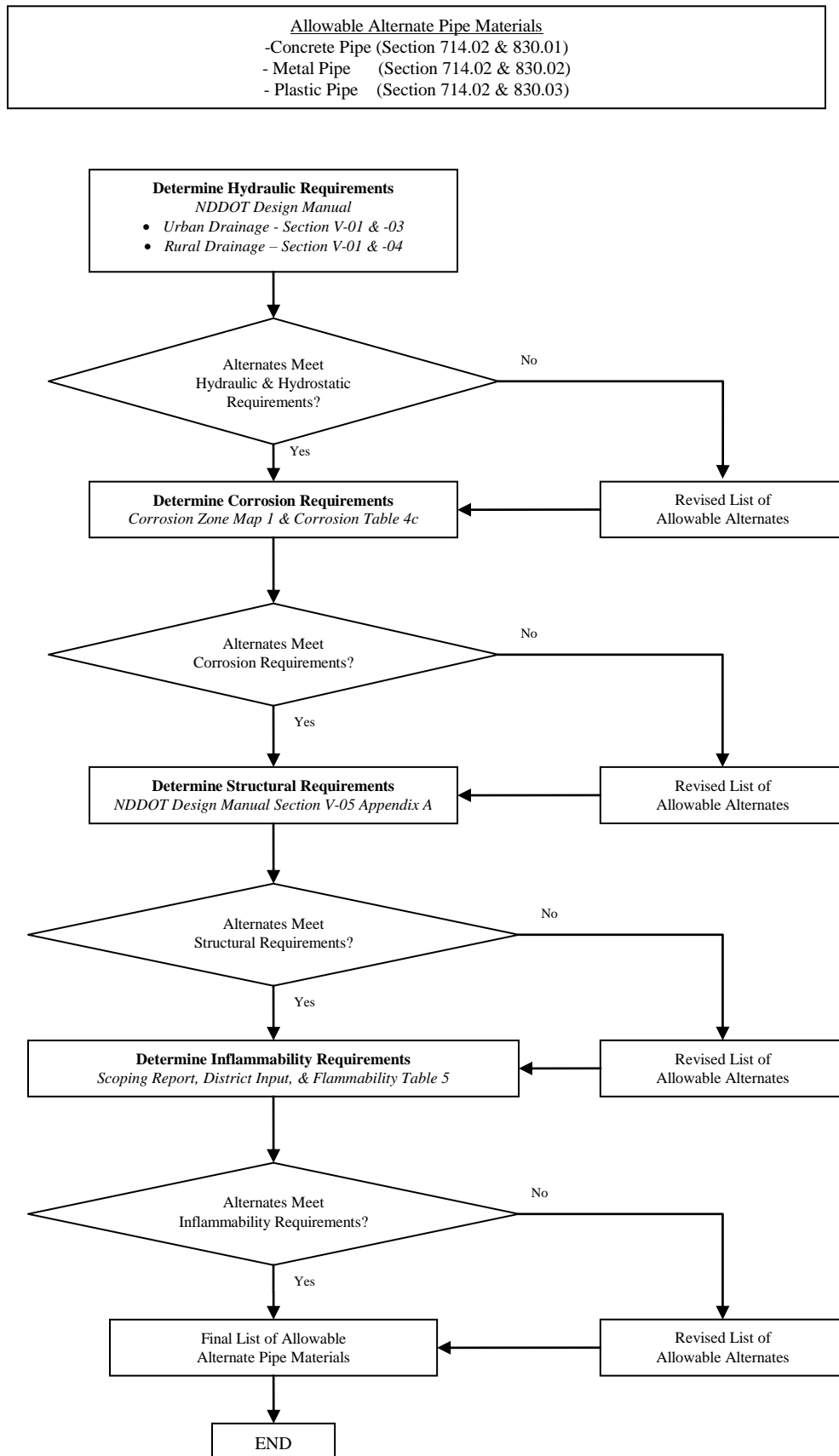


**Approach Drainage Flowchart**  
(Design Service Life – 40 Years)





**Storm Drain Trunk Line & Lateral Drainage Flowchart**  
(Design Service Life – 75 Years)



**Abrasion Table: 3a****Mainline Drainage**  
(Design Service Life – 75 Years)

Pipe Material	Abrasion Level				
	Level 1	Level 2	Level 3	Level 4	Level 5
<b>Concrete Pipe (Section 830.01)</b>	Y	Y	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>					
Zinc Coated Corrugated Steel	Y	Y			
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y		
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	Y	Y	Y	Y	
Structural Steel Plate Pipe (Zinc Coated)	Y	Y			
Aluminum Alloy Pipe	Y	Y	Y	Add 1 Gauge	Add 2 Gauges

Level 1 – No bedload – regardless of velocity.

Level 2 – Bedload of sand, gravel, and debris with velocities of 0 to 5 ft/s.

Level 3 – Bedload of sand, gravel, and debris with velocities of 5 to 10 ft/s.

Level 4 – Bedload of sand, gravel, and debris with velocities of 10 to 15 ft/s.

Level 5 – Bedload of sand, gravel, and debris with velocities greater than 15 ft/s.

**Abrasion velocities based on a 2 year design frequency.**

Source: National Corrugated Steel Pipe Association and West Virginia DOT Design Directive DD-503.

**Abrasion Table: 3b****Approach Drainage**  
(Design Service Life – 40 Years)

Pipe Material	Abrasion Level				
	Level 1	Level 2	Level 3	Level 4	Level 5
<b>Concrete Pipe (Section 830.01)</b>	Y	Y	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>					
Zinc Coated Corrugated Steel	Y	Y			
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y		
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	Y	Y	Y	Y	
Structural Steel Plate Pipe (Zinc Coated)	Y	Y			
Aluminum Alloy Pipe	Y	Y	Y	Add 1 Gauge	Add 2 Gauges
<b>Plastic Pipe (Section 830.03)</b>					
High-Density Polyethylene (HDPE)	Y	Y	Y	Y	Y

Level 1 – No bedload – regardless of velocity.

Level 2 – Bedload of sand, gravel, and debris with velocities of 0 to 5 ft/s.

Level 3 – Bedload of sand, gravel, and debris with velocities of 5 to 10 ft/s.

Level 4 – Bedload of sand, gravel, and debris with velocities of 10 to 15 ft/s.

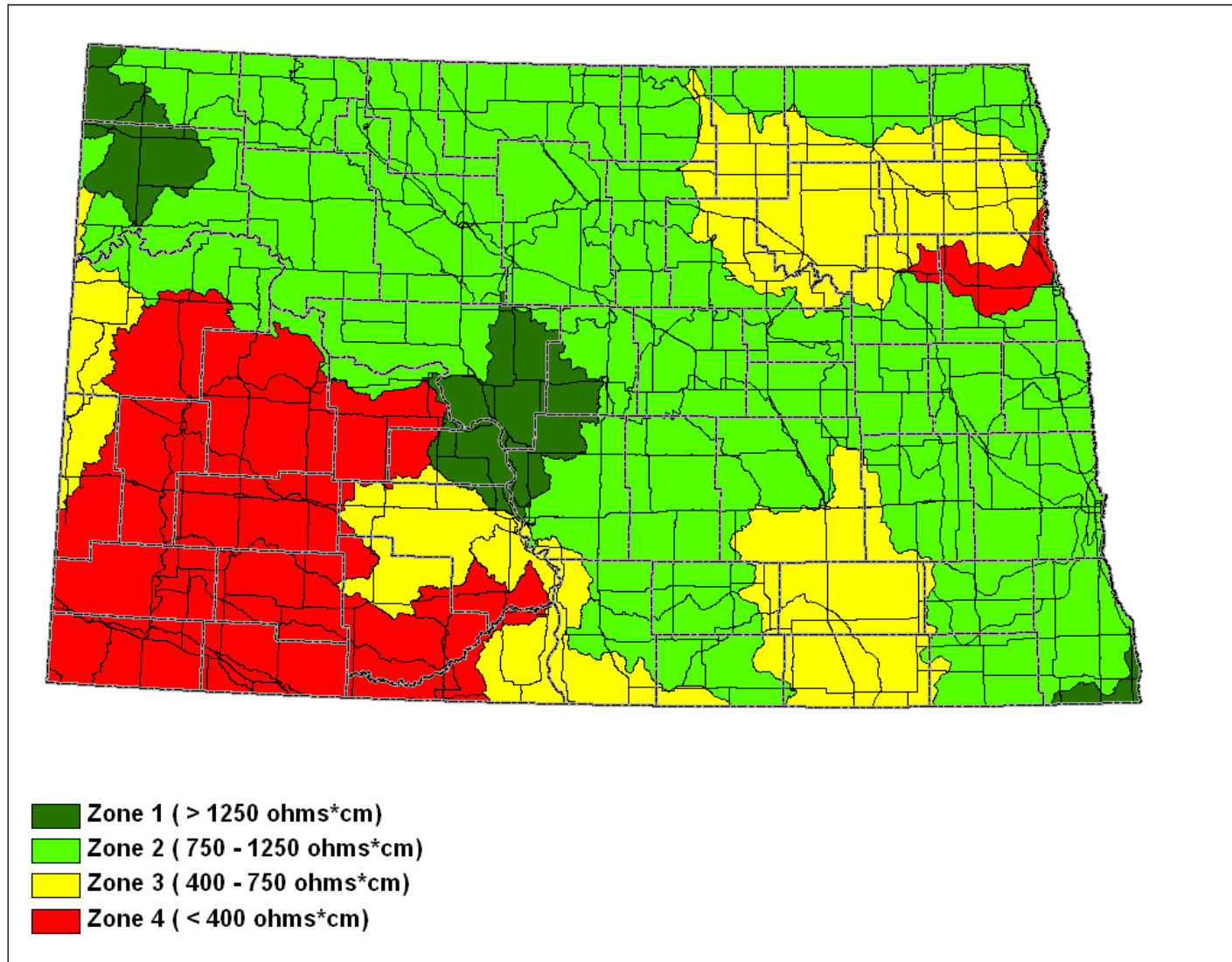
Level 5 – Bedload of sand, gravel, and debris with velocities greater than 15 ft/s.

**Abrasion velocities based on a 2 year design frequency.**

Source: National Corrugated Steel Pipe Association and West Virginia DOT Design Directive DD-503.

Corrosion Zone Map & Tables

**North Dakota Corrosion Zones (Map 1)**  
(Based on Soil Resistivity)



Data Source: United States Environmental Protection Agency's (EPA) Environmental Monitoring Assessment Program.

**Corrosion Table: 4a**

**Mainline Drainage**  
(Design Service Life – 75 Years)

		Corrosion Zone			
Pipe Material		Zone 1	Zone 2	Zone 3	Zone 4
<b>Concrete Pipe (Section 830.01)</b>		Y	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>	Gauge				
Zinc Coated Corrugated Steel	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Coated Corrugated Steel (Type 2)	16 ga.				
	14 ga.				
	12 ga.	Y			
	10 ga.	Y	Y		
	8 ga.	Y	Y	Y	
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Structural Steel Plate Pipe (Zinc Coated)	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Alloy Structural Plate Pipe	16 ga.	Y	Y		
	14 ga.	Y	Y		
	12 ga.	Y	Y		
	10 ga.	Y	Y		
	8 ga.	Y	Y		

(Based on Caltrans research formula for metal pipe service life and industry service life multipliers for coated metal pipe)

**Corrosion Table: 4b****Approach Drainage**  
(Design Service Life – 40 Years)

		Corrosion Zone			
Pipe Material		Zone 1	Zone 2	Zone 3	Zone 4
<b>Concrete Pipe (Section 830.01)</b>		Y	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>	Gauge				
Zinc Coated Corrugated Steel	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Aluminum Coated Corrugated Steel (Type 2)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Structural Steel Plate Pipe (Zinc Coated)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Aluminum Alloy Structural Plate Pipe	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
<b>Plastic Pipe (Section 830.03)</b>					
Polyvinyl Chloride (PVC)		Y	Y	Y	Y
High-Density Polyethylene (HDPE)		Y	Y	Y	Y

(Based on AISI formula for metal pipe invert life and industry service life multipliers for coated metal pipe)

**Corrosion Table: 4c**

**Storm Drain Trunk Line & Lateral Drainage**  
(Design Service Life – 75 Years)

		Corrosion Zone			
Pipe Material		Zone 1	Zone 2	Zone 3	Zone 4
<b>Concrete Pipe (Section 830.01)</b>		Y	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>	Gauge				
Zinc Coated Corrugated Steel	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Coated Corrugated Steel (Type 2)	16 ga.				
	14 ga.				
	12 ga.	Y			
	10 ga.	Y	Y		
	8 ga.	Y	Y	Y	
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	16 ga.	Y	Y	Y	Y
	14 ga.	Y	Y	Y	Y
	12 ga.	Y	Y	Y	Y
	10 ga.	Y	Y	Y	Y
	8 ga.	Y	Y	Y	Y
Structural Steel Plate Pipe (Zinc Coated)	16 ga.				
	14 ga.				
	12 ga.				
	10 ga.	Y			
	8 ga.	Y	Y		
Aluminum Alloy Structural Plate Pipe	16 ga.	Y	Y		
	14 ga.	Y	Y		
	12 ga.	Y	Y		
	10 ga.	Y	Y		
	8 ga.	Y	Y		
<b>Plastic Pipe (Section 830.03)</b>					
Polyvinyl Chloride (PVC)		Y	Y	Y	Y
High-Density Polyethylene (HDPE)		Y	Y	Y	Y

(Based on Caltrans research formula for metal pipe service life and industry service life multipliers for coated metal pipe)

**Flammability Table: 5****Pipe Material Allowable Where Burning is Anticipated**

Pipe Material	Application		
	Mainline Drainage	Approach Drainage	Storm Drain Trunk Line and Lateral Drainage
<b>Concrete Pipe (Section 830.01)</b>	Y	Y	Y
<b>Metal Pipe (Section 830.02)</b>			
Zinc Coated Corrugated Steel	Y	Y	Y
Aluminum Coated Corrugated Steel (Type 2)	Y	Y	Y
Polymeric Coated Steel (over Zinc or Aluminum Coated Steel)	N <sup>(1)</sup>	N <sup>(1)</sup>	N <sup>(1)</sup>
Structural Steel Plate Pipe (Zinc Coated)	Y	Y	Y
Aluminum Alloy Pipe	Y	Y	Y
<b>Plastic Pipe (Section 830.03)</b>			
Polyvinyl Chloride (PVC)	N/A <sup>(2)</sup>	N/A <sup>(3)</sup>	N <sup>(1)</sup>
High-Density Polyethylene (HDPE)	N/A <sup>(2)</sup>	N <sup>(1)</sup>	N <sup>(1)</sup>

## Notes:

<sup>(1)</sup> - N; plastic coated metal or plastic pipe may not be used in flammable applications without the addition of non-flammable segments and/or end treatment as determined by the Designer.

<sup>(2)</sup> - N/A; pipe not allowed for Mainline Drainage applications

<sup>(3)</sup> - N/A; pipe not allowed for Approach Drainage applications